L Number	Hits	Search Text	DB	Time stamp
1	803678	oblique or angle or angled	USPAT; US-PGPUB	2002/08/06 18:51
2	100666	implant or implantation or implanted or implants	USPAT; US-PGPUB	2002/08/06 18:51
3	3949	(oblique or angle or angled) with (implant or implantation or implanted or implants)	USPAT; US-PGPUB	2002/08/06 18:52
4	60	438/447.ccls.	USPAT; US-PGPUB	2002/08/06 18:52
5	5	((oblique or angle or angled) with (implant or implantation or implanted or implants)) and 438/447.ccls.	USPAT; US-PGPUB	2002/08/06 18:55
6	8080	locos	USPAT; US-PGPUB	2002/08/06 18:56
7	37	((oblique or angle or angled) with (implant or implantation or implanted or implants)) same locos	USPAT; US-PGPUB	2002/08/06 19:11
8	168	(438/525).CCLS.	USPAT; US-PGPUB	2002/08/06 19:11
9	32	locos and ((438/525).CCLS.)	USPAT; US-PGPUB	2002/08/06 19:11
10	28	(locos and ((438/525).CCLS.)) not (((oblique or angle or angled) with (implant or implantation or implanted or implants)) same locos)	USPAT; US-PGPUB	2002/08/06 19:28
11	271361	trench or recess	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:29
12	792879	oblique or angle or angled	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:29
13	94552	implant or implanted or implantation or implants	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:29
14	250	(trench or recess) and (oblique or angle or angled) and (implant or implanted or implantation or implants)	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:30
15	176746	locos or oxidation	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:30
16	16	((trench or recess) and (oblique or angle or angled) and (implant or implanted or implantation or implants)) and (locos or oxidation)	EPO; JPO; DERWENT; IBM_TDB	2002/08/06 19:30

L Number	Hits	Search Text	DB	Time stamp
1	803678	oblique or angle or angled	USPAT; US-PGPUB	2002/08/06 18:51
2	100666	implant or implantation or implanted or implants	USPAT; US-PGPUB	2002/08/06 18:51
3	3949	(oblique or angle or angled) with (implant or implantation or implanted or implants)	USPAT; US-PGPUB	2002/08/06 18:52
4	60	438/447.ccls.	USPAT; US-PGPUB	2002/08/06 18:52
5	5	((oblique or angle or angled) with (implant or implantation or implanted or implants)) and 438/447.ccls.	USPAT; US-PGPUB	2002/08/06 18:55
6	8080	locos	USPAT; US-PGPUB	2002/08/06 18:56
7	37	((oblique or angle or angled) with (implant or implantation or implanted or implants)) same locos	USPAT; US-PGPUB	2002/08/06 19:11
8	168	(438/525).CCLS.	USPAT; US-PGPUB	2002/08/06 19:11
9	32	locos and ((438/525).CCLS.)	USPAT; US-PGPUB	2002/08/06 19:11
10	28	(locos and ((438/525).CCLS.)) not (((oblique or angle or angled) with (implant or implantation or implanted or implants)) same locos)	USPAT; US-PGPUB	2002/08/06 19:11

TDB-ACC-NO: NN7408949

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3p. An improved process which minimizes the width of the recessed oxide (ROX) region, thereby providing higher packing density of active devices, and which minimizes the spread of additional boron at the sides of the ROX region, thereby separating the boron channel stopper from the implanted or diffused regions of

active devices at
the silicon surface, is described. Minimizing the spread of the
boron channel stopper, leads to better electrical isolation of active
devices and reduced leakage from device to substrate for p-type
silicon substrates.

- In a known process, an anisotropic etch was used to define a
steep walled and flat bottomed hole or recess in (110) or (100)
silicon. Subsequently, a thermal oxide (ROX) was grown in the recess.
The advantage of the anisotropic etch over an isotropic etch is that
the width of the ROX region is less, allowing higher packing density
of active devices at the silicon surface. For p-type silicon
substrates, boron was ion implanted after etching the recess to
compensate for boron depletion which occurs during growth of the
thermal oxide.

- Using this prior art process, an SiO(2) layer approximately
4000 Angstroms thick was used as the implantation mask. A major
problem associated with this thick SiO(2) implantation mask is that
even though a very steep walled hole or recess

can be opened in the
resist using electron-beam techniques, excessive undercutting of the
SiO(2) mask occurs during etching. The lateral undercutting is
approximately equal to the SiO(2) thickness.

- Furthermore, since the SiO(2) walls are sloped at an angle of
approximately 45 degrees, the implantation masking capability is not
100% at the edges of the mask. This can produce an undesirably
high-boron concentration on the side walls of the ROX region at the
silicon surface. As a result, implanted or diffused source and drain
regions of active devices immediately adjacent to the ROX region may
exhibit reduced breakdown and/or excessive junction leakage.

- If a photoresist layer is used as an ion implantation mask,
rather than a thick SiO(2) layer, then a much thinner SiO(2) layer
(e.g., less than 500 Angstroms) can be used, thereby relieving the
SiO(2) undercutting problem discussed above. Fig. 1 shows a
photoresist mask 1 having a thickness of 5000 Angstroms deposited on
a layer 2 of SiO(2) having a thickness of 500 Angstroms and a layer 3

of Si(3)N(4) having a thickness of 500 Angstroms on a silicon
substrate 4. The eventual mask opening 5 at the silicon surface will
be 5000 Angstroms plus 500 Angstroms (for the SiO(2) mask) plus 500
Angstroms (for the Si(3)N(4)), or 6000 Angstroms total. Then the
width of the ROX region will be 6000 Angstroms plus 80% x 4000
Angstroms (for the ROX undergrowth) or 9200 Angstroms total.

- If an SiO(2) mask of 4000 Angstrom thickness is used, the mask
opening at the silicon surface would be 5000 Angstroms plus 4000
Angstroms plus 500 Angstroms or 9500 Angstro total, and the eventual
Width of the ROX region would be 9500 Angstroms plus 80% x 4000
Angstroms, or 12,700 Angstroms total. In Fig. 1, the SiO(2) is
removed using well-known photolithographic masking and etching
techniques.

- For p-type substrates, boron (as indicated by arrows 6 in Fig.
2) will be ion implanted into the silicon 4 through the Si(3)N(4)
layer 3, forming an implanted region 7 in the silicon 4. It should
be noted that boron is implanted prior to etching

either the Si(3)N(4) layer 3 or the silicon 4, because etchants for these materials attack the resist layer 1. The portion of the SiO(2) layer 2 to be removed in opening 5 can be removed either before or after the boron implantation, as desired. Both layers 2 and 3 are necessary in the process; the SiO(2)layer 2 to define a hole in Si(3)N(4)layer 3, and the Si(3)N(4)layer 3 to prevent ROX growth over selected areas of the surface of silicon wafer 4.

Fig. 3 shows the structure after removal of that portion of the Si(3)N(4)layer 3 over implanted region 7, using layer 2 as an etching mask. Si(3)N(4) can be removed using well-known etches such as H(3)PO(4). Fig. 4 shows the result of a subsequent step in which an anisotropic etch such as KOH is utilized to form a 2000 Angstroms deep recess 8 in silicon 4 using layer 3 as an etching mask. Note that a portion of the boron implanted region 7 is also removed.

Next, the remaining portions of the SiO(2)layer 2 are removed by conventional etches. Finally, ROX region 10 is formed by thermal

oxidation of silicon 4 as shown in Fig. 5.
- Annealing and diffusion of the implanted boron occurs during
the high-temperature growth of ROX region 10, which is accomplished
by a dry-wet-dry thermal oxidation at 1000 degrees C for
approximately 90 minutes. During this thermal cycle, the boron
implanted region 7 outdiffuses leaving a doping greater than 5 x
10/16/ at the Si-SiO(2) interface, as shown in Fig. 5. The boron
implantation parameters are: dose 5x10/12/ cm/-2/, energy 100 KeV,
range 3000 Angstroms, and standard deviation 600 Angstroms. Under
these conditions, the resist layer 1 is not expected to polymerize
and can still be easily removed with conventional etches.
- The above process offers the following advantages:
1. Instead of using a thick SiO(2) layer for both Si(3)N(4)
delineation and boron implantation masking, a thin SiO(2) layer is
used for Si(3)N(4) delineation and a resist layer with vertical walls
is used for implantation masking. This results in a reduction of the
width of ROX region 10 from 12700 Angstroms to

9200 Angstroms for comparable processes.

- 2. The resist layer can be made quite thick (e.g., 5000 Angstroms), thus giving a high degree of implant masking.
- 3. The walls of the resist layer can be made much steeper than the walls of an etched SiO(2) layer, thereby giving a very steep walled implant region 7. The ROX region 10 extends beyond the implanted boron region 7 near the silicon surface, leaving a p-type channel stopper 9 beneath the ROX region 10 and on the ROX sidewalls but well separated from the surface of the silicon, as shown in Fig. 5.
- 4. The same resist mask may be utilized in situations where another ionic species is used, to help define the depth and flatness of recess 8 prior to etching of silicon 4.

FIG. 1

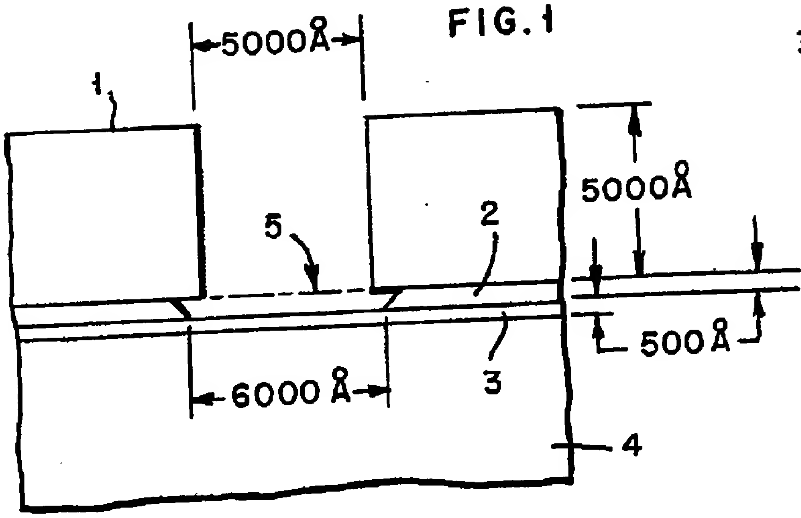

FIG. 3

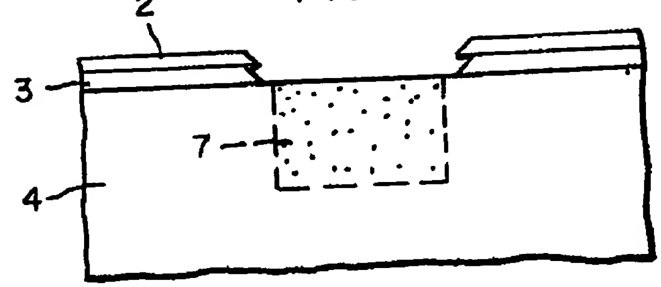

FIG. 4

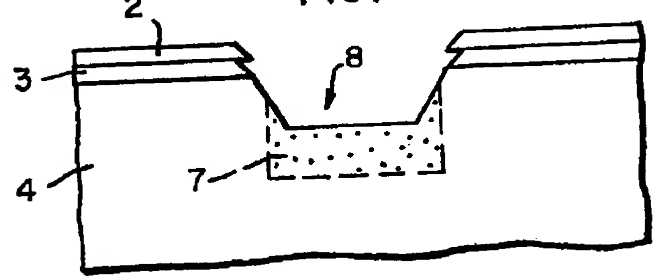

FIG. 2

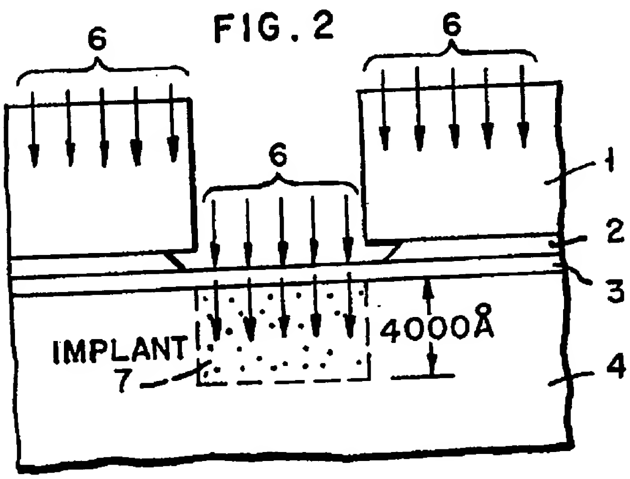

FIG. 5